ZOOLOGY.—*Muscles of the hip and thigh of the emperor penguin.*

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Some emperor penguins, *Aptenodytes fosteri*, recently brought from the Antarctic to the zoo at Portland, Oreg., died from an epidemic of aspergillosis. After autopsy, some parts of the bodies of the dead birds were in a satisfactory condition for anatomical study. The musculature of the hip and thigh was one of such parts.

METHOD

One specimen was prepared to show the skeleton of the region; another, the musculature. The latter was preserved in a solution made of a mixture of equal parts of 4-percent formaldehyde, glycerine, and 95-percent alcohol. This specimen was used for the dissection of the muscles.

The function of each muscle was determined by pulling on the muscle from near the point of insertion toward the point of origin.

The descriptions of the muscles of the hip and thigh of a penguin, *Eudyptes chrysocome*, by Watson (1883) were used as a guide.

Although Watson in his work on *Eudyptes chryosocome* considered the trunk to be in a horizontal position, the natural vertical position of the trunk is taken as the basis of orientation in the present study.

RESULTS

The bones serving for the attachment of the muscles of the hip and thigh are shown in the accompanying labeled photograph (Fig. 1).

In both the fresh and the preserved conditions, the muscles are very dark red-brown. Their strong fishy odor remains even after the addition of the above preservative.

The superficial muscles of the lateral aspect of the hip and thigh (Fig. 2) are the following:

Sartorius. This is a very large, elongated muscle and the most cephalic of all the muscles of the thigh. It originates by an aponeurosis from about 2.5 cm of the cranial end of the coalesced spinous processes of the lumbosacral portion of the vertebral column and the spinous process of the four thoracic vertebrae immediately above. It arises also along the dorsolateral edge of the cephalic end of the ilium. The fibers pass obliquely to the insertion of the muscle on the anterocephalic part of the patella.

Sartorius flexes the thigh and extends the leg.

Rectus femoris. The cephalic portion of the musculoaponeurotic sheet that covers the lateral surface of the thigh is rectus femoris. It arises by an aponeurosis from the coalesced spinous processes of the lumbosacral portion of the vertebral column. The fibers run transversely to the insertion which is by a tendon in common with the tendon of extensor cruris (Fig. 3) to the posterior side of the patella.

Rectus femoris flexes the thigh and extends the leg.

Tensor fasciae femoris. The caudal portion of the musculoaponeurotic sheet that covers the lateral surface of the thigh is tensor fasciae femoris. It originates from the coalesced spinous processes of the lumbosacral vertebrae by an aponeurosis shared with rectus femoris. The fibers take a transverse course, and the insertion is by a tendon into the posterocaudal part of the patella and the cephalic end of the lateral upper tibial crest (Fig. 1).

This muscle extends the thigh and flexes the leg.

Biceps femoris. This is a large muscle immediately caudad of tensor fasciae femoris. It originates along the posterior border of the innominate bone and on the caudal margin of the tendon of origin of the tensor fasciae femoris. Its fibers run laterally and slightly caudally to the insertion which is made by a tendon on a tubercle on the outer side of the fibula at the junction of the upper and middle thirds of that bone (Fig. 1). The tendon of insertion passes through a loop of a band-like tendon extending from the distal end of the lateral surface of the shaft of the femur to the tendinous outer head of origin of a leg muscle (gastrocnemius). The loop is thickened where it makes a sharp bend around the caudal border of the tendon of biceps femoris.

The sciatic nerve lies just below biceps fem-

oris and runs almost parallel to the long axis of this muscle. As soon as the nerve makes its exit from the pelvis, it sends branches into biceps femoris (Fig. 3).

Biceps femoris is an effective flexor of the leg.

Semitendinosus. Semitendinosus is a large muscle situated immediately caudad of biceps femoris and is essentially as wide as that muscle. Semitendinosus arises from the most posterior part of the caudal processes of the innominate bone. It also arises from the transverse processes of the third, fourth and fifth caudal vertebrae. Most of the fibers pass essentially in the transverse plane. Insertion is by a ribbonlike tendon about 3.75 cm long and 1.25 cm wide into the distal end of the medial upper tibial crest (Fig. 1).

This muscle flexes the leg and extends the thigh. If the knee joint be flexed, the posterior fibers depress the tail.

The deep muscles of the hip and thigh (Fig. 3) are as follows:

Gluteus medius. Gluteus medius is a large muscle. It arises from the whole posterior surface of the ilium and from the lateral surface of some of the coalesced spinous processes of the lumbosacral region. The fibers run caudolaterad and are inserted by a tendon on the greater tro-

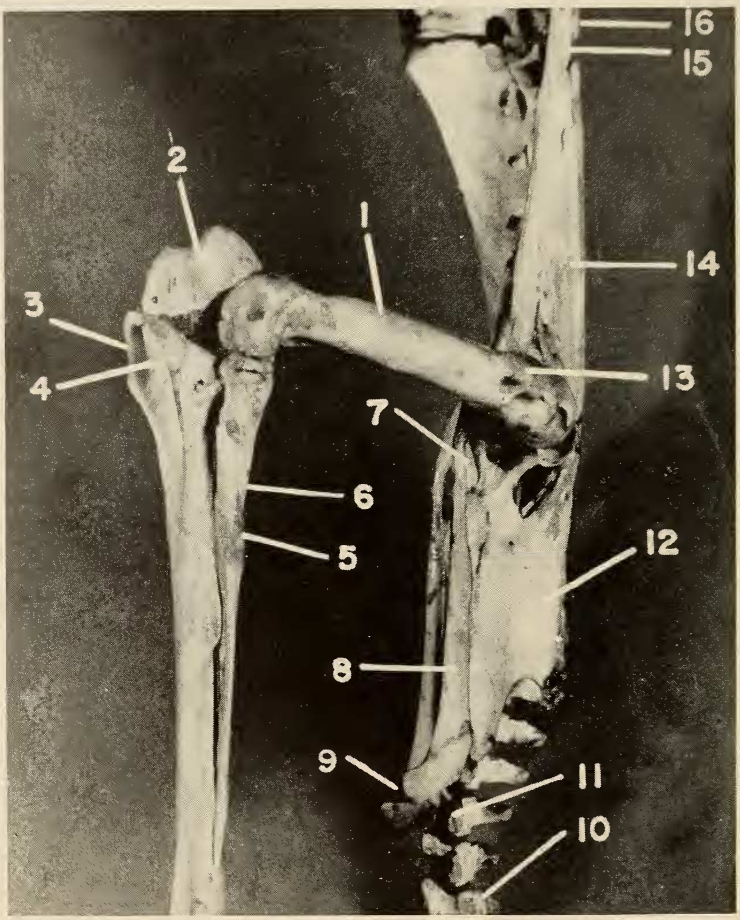

FIG. 1.—Lateral aspect of the portion of the skeleton of *Aptenodytes fosteri* to which muscles of the hip and thigh have attachment. Not all the thoracic vertebrae involved are shown. 1, Shaft of the femur. 2, Groove on the patella for the tendon of musculus ambiens. 3, Medial upper tibial crest. 4, Lateral upper tibial crest. 5, Tubercle of the fibula. 6, Groove on the fibula for the tendon of musculus ambiens. 7, Obturator foramen. 8, Pubic portion of the innominate bone. 9, Cartilaginous tip of the pubic bone. 10, Pygostyle. 11, Transverse process of a caudal vertebra. 12, Ischium portion of the innominate bone. 13, Greater trochanter. 14, Coalesced spinous processes of the lumbosacral portion of the vertebral column. 15, Ilium portion of the innominate bone. 16, Spinous process of a thoracic vertebra.

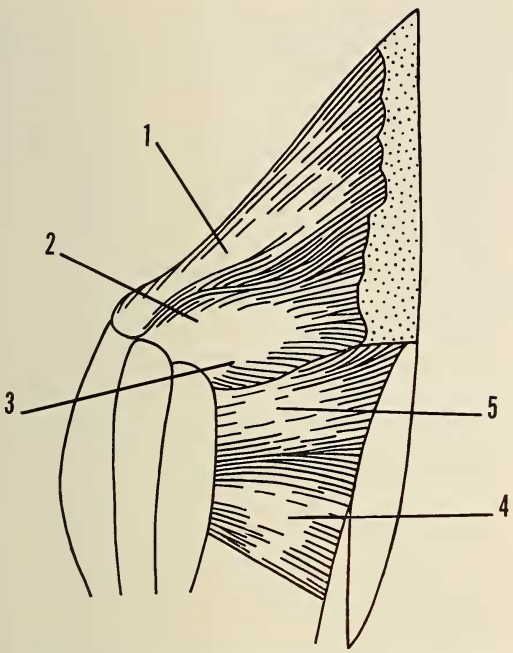

FIG. 2.—Superficial muscles of the lateral aspect of the hip and thigh of *Aptenodytes fosteri*. 1, Sartorius. 2, Rectus femoris. 3, Tensor fasciae femoris. 4, Semitendinosus. 5, Biceps femoris.

chanter of the femur and to a lesser extent on the articular capsule of the hip joint.

The cephalic third of gluteus medius is concealed by sartorius; the caudal two-thirds are covered by the aponeurosis of origin common to rectus femoris and tensor fasciae femoris.

Gluteus medius rotates the hip joint medially.

Gluteus minimus. Gluteus minimus is smaller than gluteus medius. It originates along the lateral border of the ilium and from a tendinous sheet between it and gluteus medius. The fibers run caudolaterad and insert by a tendon on the greater trochanter of the femur anterolaterad of the insertion of gluteus medius.

Much of the posterior surface of gluteus minimus is covered by gluteus medius.

Gluteus minimus rotates the hip joint medially.

A third gluteal muscle has not been recognized in penguins.

Extensor cruris. Extensor cruris is a large muscle mass which originates from the lateral and cephalic surfaces of the shaft of the femur. The part on the cephalic surface is much larger than the part on the lateral surface, and it arises about 2.5 cm more proximally than that on the lateral surface. The cephalic part inserts into the upper truncated extremity of the patella. The lateral part inserts into the tendon of tensor fasciae femoris and hence reaches the lateral surface of the patella and the cephalic end of the lateral upper tibial crest.

Extensor cruris is covered laterally by the musculoaponeurotic sheet formed by rectus femoris and tensor fasciae femoris.

Extensor cruris functions as an important extensor of the leg.

Adductor longus. This muscle arises from about 3 cm of the posterior border of the ischium portion of the innominate bone. The fibers run obliquely to the point of insertion near the distal end of the caudal border of the shaft of the femur.

Adductor longus is crossed laterally by the sciatic nerve. This nerve and adductor longus are concealed by biceps femoris. At its origin, the adductor longus crosses obturator externus;

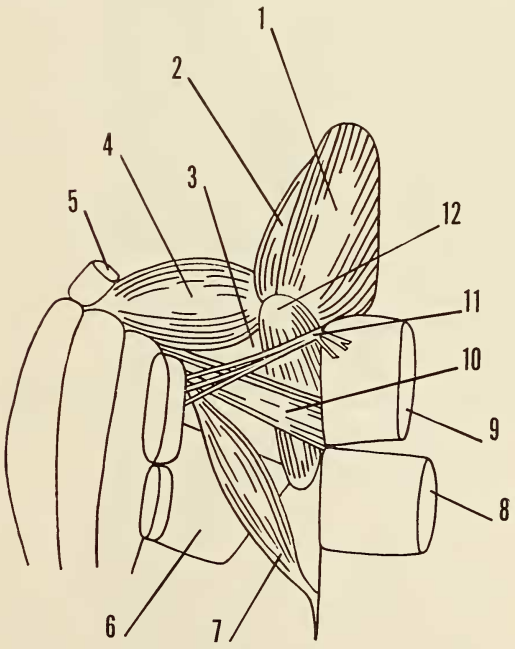

FIG. 3.—Lateral surface of the deep muscles of the hip and thigh of *Aptenodytes fosteri*. Sartorius has been cut off at its insertion. Rectus femoris and tensor fasciae femoris have been entirely removed. Also biceps femoris and semitendinosus have been bisected and their cut ends reflected. 1, Gluteus medius. 2, Gluteus minimus. 3, Adductor magnus. 4, Extensor cruris. 5, Sartorius. 6, Semimembranosus. 7, Crurococcygeus. 8, Semitendinosus. 9, Biceps femoris. 10, Adductor longus. 11, Sciatic nerve. 12, Obturator externus.

at its insertion, it makes contact with adductor magnus. Its tendon of insertion unites with that of crurococcygeus.

The action produced by adductor longus is extension of the thigh.

Crurococcygeus. Crurococcygeus is a long muscle, tapering at each end and measuring over 22.5 cm from the origin to the insertion. It arises by a flat tendon for a distance of 1.25 cm from the cephalolateral border of the pygostyle. The tendon becomes slender and rounded before joining the muscle proper. The muscle fibers take an oblique course; and insert by a long, narrow tendon into the lateral side of the shaft of the femur distad to the tendon of insertion of adductor longus to which it is fused. Just distad to the insertion of crurococcygeus is the attachment of the upper end of the fibrous pulley through which the tendon of insertion of biceps femoris passes.

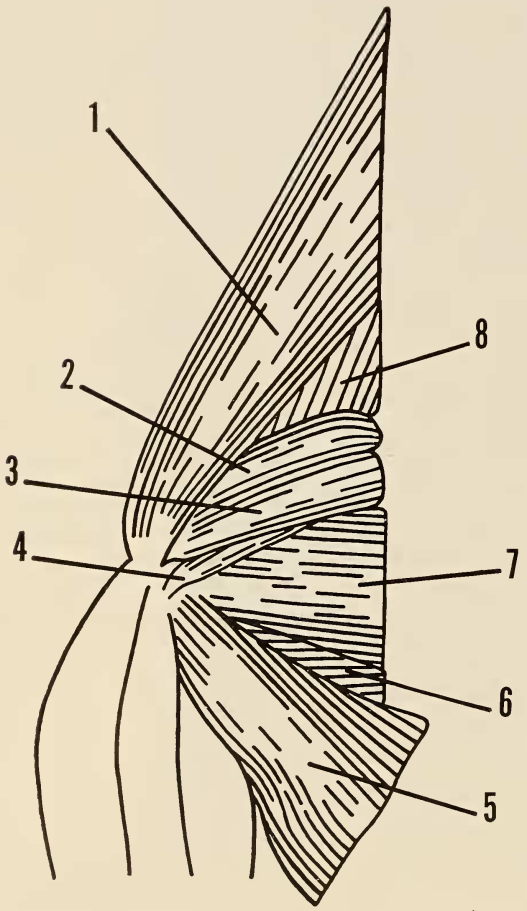

FIG. 4.—Superficial muscles of the medial aspect of the hip and thigh of *Aptenodytes fosteri*. 1, Sartorius. 2, Extensor cruris. 3, Musculus ambiens. 4, Gracilis. 5, Semimembranosus (abdominal head). 6, Semimembranosus (pubic head). 7, Adductor magnus. 8, Gluteus minimus.

Crurococcygeus is covered by semitendinosus and biceps femoris laterally and by semimembranosus and adductor magnus medially.

Acting with its fellow of the opposite side, crurococcygeus depresses the tail. If the tail be fixed, the muscle is an extensor of the thigh.

Obturator externus. Obturator externus arises from the whole lateral surface of the innominate bone caudad of the acetabulum, exclusive of the pubic part of this bone. The fibers run cephalolaterad to the tendon of insertion on the greater trochanter of the femur just caudad of the tendon of insertion of gluteus minimus.

Laterally the muscle is crossed by adductor longus and the sciatic nerve.

Obturator externus rotates the thigh laterally. It is an antagonist of gluteus medius and gluteus minimus.

Obturator internus. Obturator internus (not shown in the figure) is an elongated oval muscle. It arises from the greater part of the medial surface of the ischium, the pubis and the membrane between these two bones. The fibers pass cephalad and end on a tendon which passes through the obturator foramen and which is inserted on the greater trochanter of the femur mediad of the insertion of obturator externus.

Since this muscle lies on the inner side of the bony pelvis, only its tendon is in contact with obturator externus.

Obturator internus assists obturator externus in lateral rotation of the thigh.

Gemellus. Gemellus (not shown in the figure) is small and quadrilateral. It arises from the lateral side of the innominate bone close to the margin of the obturator foramen. The muscle is divided into two slips by the tendon of insertion of obturator internus. The fibers run laterad to the insertion on the caudal border of the greater trochanter of the femur just mediad to the tendon of insertion of obturator internus.

The muscle is concealed by the insertion of obturator externus.

Gemellus is a lateral rotator of the thigh.

The superficial muscles of the medial aspect of the hip and thigh (Fig. 4) are the following:

Musculus ambiens. This is a flat, superficial muscle on the medial side of the thigh. It has

an origin of about 3.75 cm from the lateral margin of the cephalic end of the pubic bone. It extends toward the knee and tapers to a tendon which is 0.6 cm wide and 11.25 cm long. This tendon crosses the front of the knee joint in a groove on the patella and in a groove on the lateral side of the proximal one third of the fibula (Fig. 1). Then this tendon passes medially to the tendon of insertion of biceps femoris and joins the head of a leg muscle (flexor perforatus digitorum) which arises from the lateral side of the distal end of the femur. The part of the tendon that passes over the surface of the groove on the patella has a marked thickening.

On its deep side, musculus ambiens makes contact with gracilis. The part of the tendon of insertion that lies in the groove on the patella is concealed by the distal end of sartorius.

Musculus ambiens adducts the thigh and extends the leg.

Gracilis. Gracilis is a slender muscle that arises from the whole medial surface of the shaft of the femur. It inserts by a tendon on the medial side of the proximal end of the medial upper tibial crest.

This muscle lies between the origin of extensor cruris and the insertion of adductor magnus. The medial surface of the major part of it is covered by musculus ambiens.

Gracilis extends the thigh.

Adductor magnus. This is a large, thick muscle. It arises from the lateral side of the pubis, ischium and the membrane between these two bones for a distance of 9.37 cm from the obturator foramen to a point 1.25 cm distant from the cartilaginous tip of the pubic bone. The fibers pass transversely to the insertion on the caudal surface of the distal half of the femur. Some of the insertion is by a special tendon on the area just above the internal condyle of the femur. To this tendon some fibers of a leg muscle (gastrocnemius) are attached.

Laterally the muscle makes contact with adductor longus and crurococcygeus.

Adductor magnus adducts and extends the thigh.

Semimembranosus. Semimembranosus is a large, flat muscle. It has two heads of origin: pubic and abdominal. The pubic head arises from the following: (1) the lateral side of the distal end of the pubic bone, including a part of the cartilaginous tip of that bone; (2) the lateral side of the adjacent distal end of the ischium; and (3) the lateral side of the caudal end of the membrane between the pubis and ischium. The abdominal head arises from the lateral surface of the abdominal wall where it is attached to the aponeurosis of the abdominal muscles for a distance of about 12.5 cm running parallel to the long axis of the body.

The fibers of both heads of origin extend to a common insertion which is on the medial side of the medial upper tibial crest. This insertion is a linear one of 5 cm, with additional fibers at the cephalic end attached to the medial side of the patella.

Laterally the pubic head makes contact with crurococcygeus and semitendinosus. Cephalically it is in contact with adductor magnus.

Semimembranosus extends the thigh and flexes the leg.

SUMMARY

1. The morphology of the muscles of the hip and thigh of the emperor penguin, *Aptenodytes fosteri*, is very similar to that given by Watson for *Eudyptes chrysocome*. However, the muscle which he described as pectineus was found to be represented in *Aptenodytes fosteri* by only a ligament.

2. As suggested by Watson the possession of an abdominal head by semimembranosus is possibly a unique feature in the anatomy of penguins.

LITERATURE CITED

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